Tevatron combined top quark mass

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On behalf of CDF and D0 collaborations

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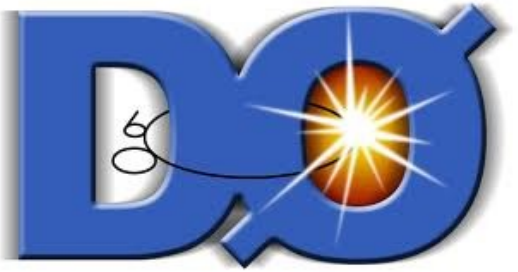


Motivation

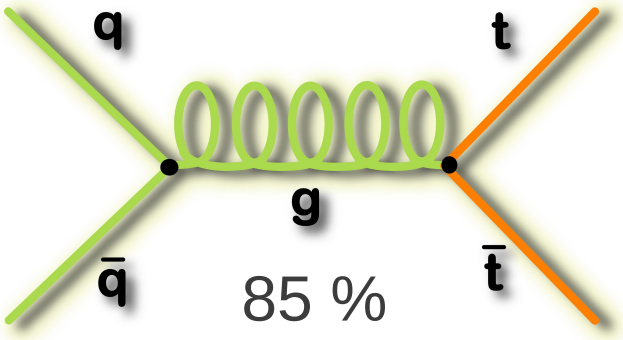
- Top quark mass value is close to the scale of electroweak symmetry breaking (EWSB):
  → does ***top*** quark have more fundamental role in EWSB?

- Huge mass gives importance to QCD corrections for **top** quark

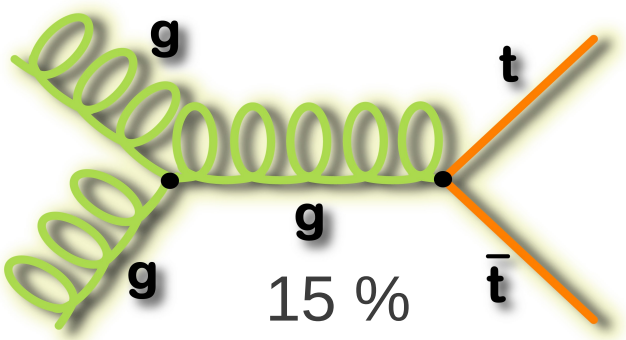
- Top sector is expected to be sensitive to new physics

Production and decays

- At Tevatron, top quark is mainly produced in $t\bar{t}$ pairs:



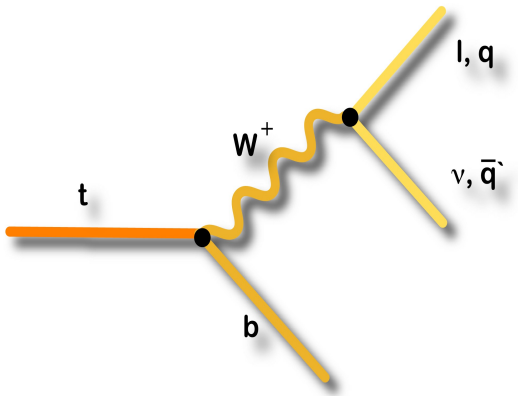
85 %

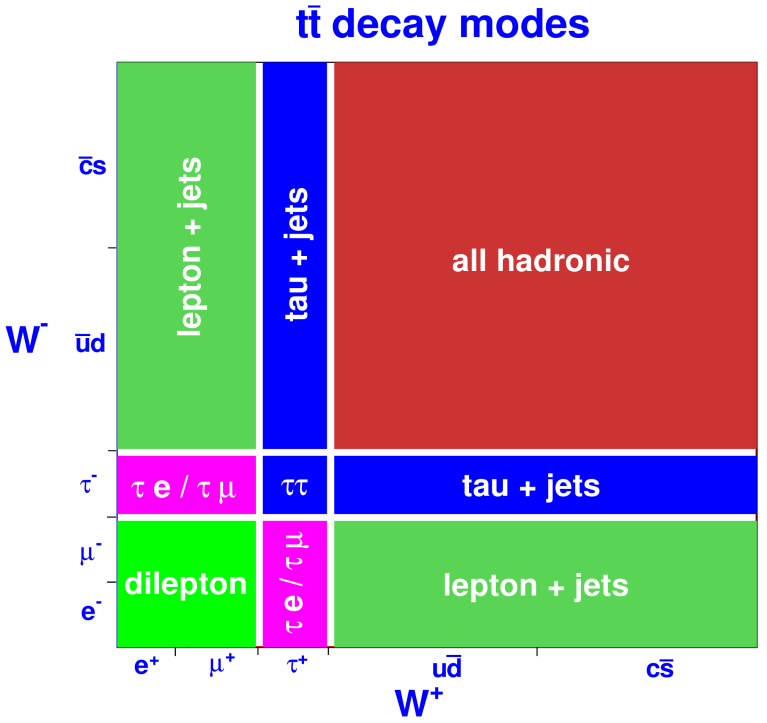


15 %

According to SM:

$$\Gamma(t \to Wb) \sim 100\,\%$$





Channels:

→ lepton+Jets ~ 30%

→ dilepton ~ 5%

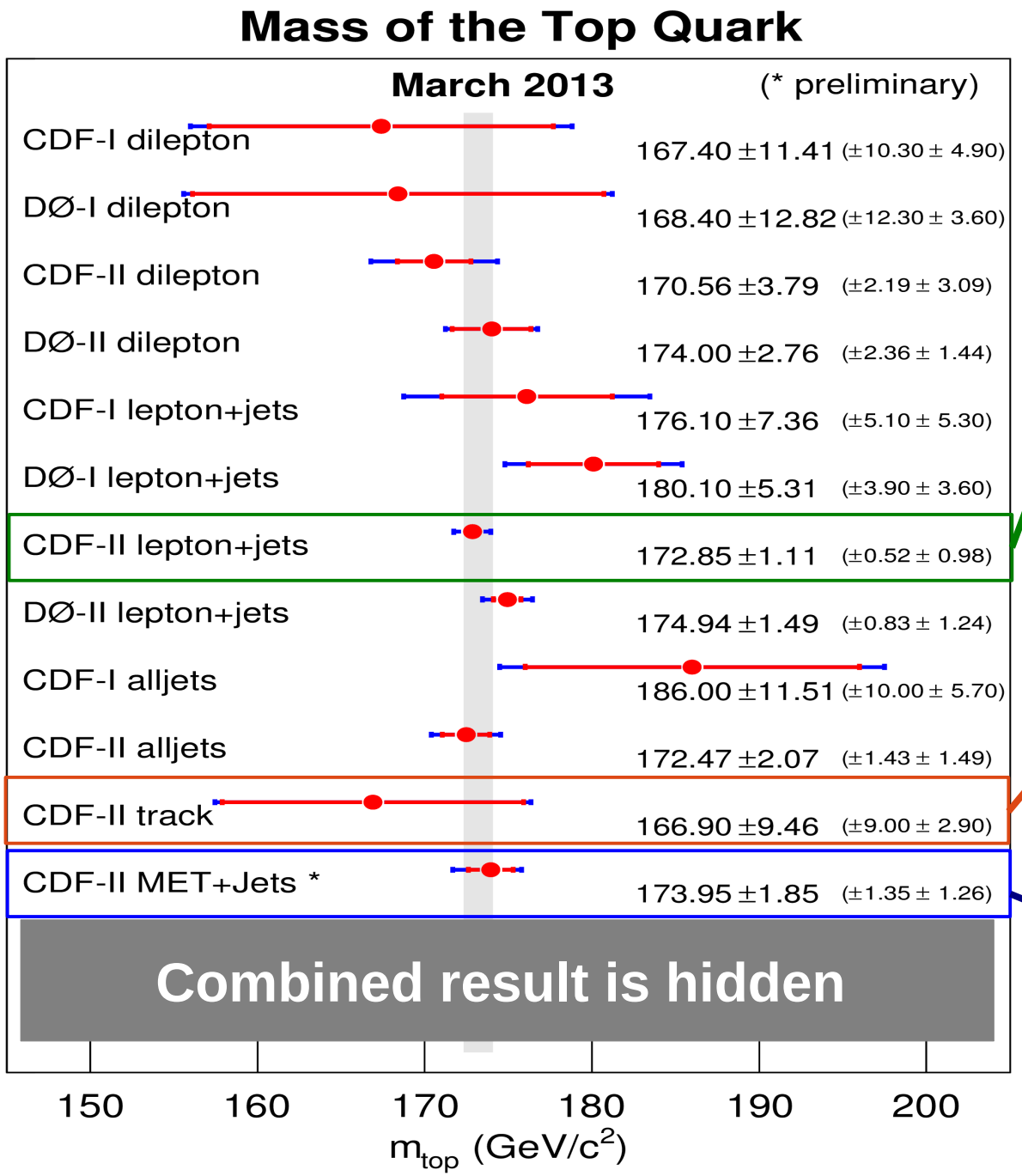
→ all hadronic ~ 44%

lepton = ***e*** or μ

Input measurements

- 12 input measurements:
  - CDF Run I
    - → LJ channel, L= 0.1 fb^{-1}
    - → DIL channel, L= 0.1 fb^{-1}
    - → All Had channel, L= 0.1 fb^{-1}
  - D0 Run I
    - → LJ channel, L= 0.1 fb^{-1}
    - → DIL channel, L= 0.1 fb^{-1}
  - CDF Run II
    - → LJ channel, L= 8.7 fb^{-1}
    - → DIL channel, L= 5.6 fb^{-1}
    - → All Had channel, L= 5.8 fb^{-1}
    - → Decay length significance, L= 1.9 fb^{-1}
    - → Missing transverse energy+jets, L= 8.7 fb^{-1} - preliminary
  - D0 Run II
    - → LJ channel, L= 3.6 fb^{-1}
    - → DIL channel, L= 5.3 fb^{-1}

Inputs measurements (II)

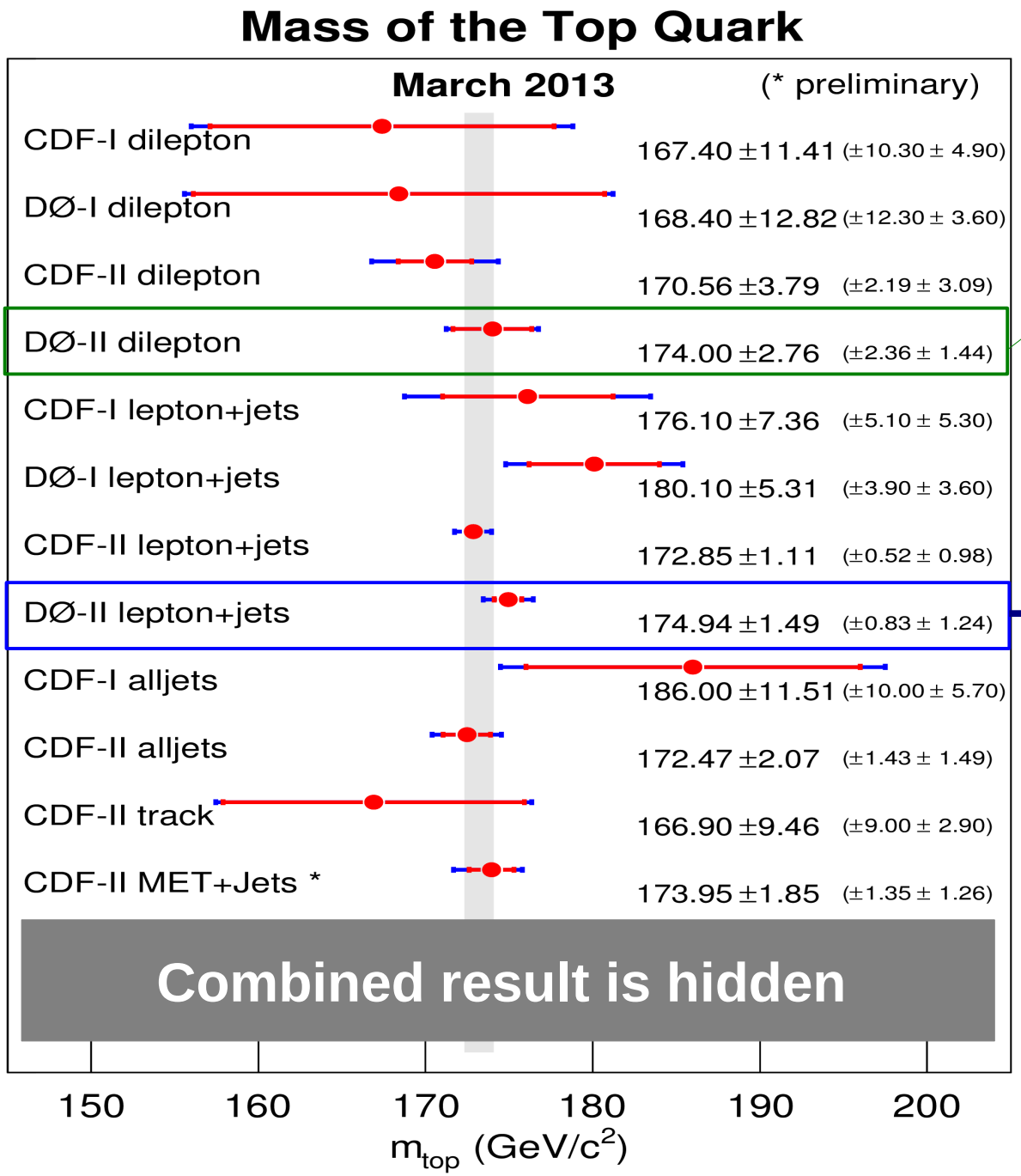


- Updated **using 8.7 fb^{-1} of data**
- improved analysis technique
- improved jet energy resolution

- **uses** primarily **tracking information**
- almost entirely **independent of JES** uncertainties.

- Updated **using 8.7 fb^{-1} of data**

Inputs measurements (III)



Uses **JES determined in Lepton+Jets channel** by *in situ* calibration

additional constraint to *in situ* **JES calib.:**
→ **determined from** the external calib. derived from γ **+jets events.**

Combination of the measurements

- two independent methods:
  - → numerical χ^2 minimization
  - → analytic BLUE method (weight of each meas. calculated from correlation coefficients)
- the methods are mathematically equivalent and give identical results for the combination.
- Correlation coefficients:

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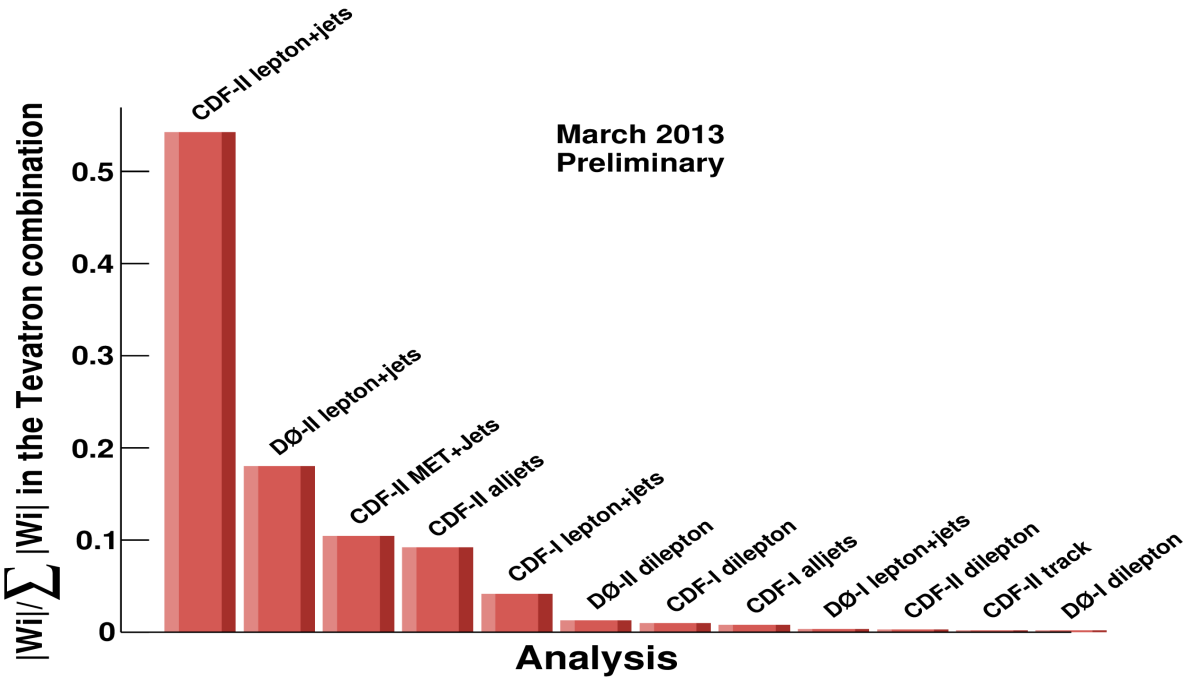
	Run I published					Run II published						Run II preliminary
	CDF			DØ		CDF				DØ		CDF
	ℓ+jets	$\ell\ell$	alljets	ℓ+jets	$\ell\ell$	ℓ+jets	$\ell\ell$	alljets	L_{XY}	ℓ+jets	$\ell\ell$	MEt
CDF-I ℓ+jets	1.00	0.29	0.32	0.26	0.11	0.49	0.54	0.25	0.07	0.21	0.12	0.27
CDF-I $\ell\ell$	0.29	1.00	0.19	0.15	0.08	0.29	0.32	0.15	0.04	0.13	0.08	0.17
CDF-I alljets	0.32	0.19	1.00	0.14	0.07	0.30	0.38	0.15	0.04	0.09	0.06	0.16
DØ-I ℓ+jets	0.26	0.15	0.14	1.00	0.16	0.22	0.27	0.12	0.05	0.14	0.07	0.12
DØ-I $\ell\ell$	0.11	0.08	0.07	0.16	1.00	0.11	0.13	0.07	0.02	0.07	0.05	0.07
CDF-II ℓ+jets	0.49	0.29	0.30	0.22	0.11	1.00	0.48	0.29	0.08	0.30	0.18	0.33
CDF-II $\ell\ell$	0.54	0.32	0.38	0.27	0.13	0.48	1.00	0.25	0.06	0.11	0.07	0.26
CDF-II alljets	0.25	0.15	0.15	0.12	0.07	0.29	0.25	1.00	0.04	0.16	0.10	0.17
CDF-II L_{XY}	0.07	0.04	0.04	0.05	0.02	0.08	0.06	0.04	1.00	0.06	0.03	0.04
DØ-II ℓ+jets	0.21	0.13	0.09	0.14	0.07	0.30	0.11	0.16	0.06	1.00	0.39	0.18
DØ-II $\ell\ell$	0.12	0.08	0.06	0.07	0.05	0.18	0.07	0.10	0.03	0.39	1.00	0.11
CDF-II MEt	0.27	0.17	0.16	0.12	0.07	0.33	0.26	0.17	0.04	0.18	0.11	1.00

Weights of the measurements

- Absolute value of weights of inputs measurements (left)



- Table of weights of inputs measurements:

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	Run I published					Run II published						Run II preliminary
	CDF			DØ		CDF				DØ		CDF
	ℓ+jets	$\ell\ell$	alljets	ℓ+jets	$\ell\ell$	ℓ+jets	$\ell\ell$	alljets	Lxy	ℓ+jets	$\ell\ell$	MEt
	ℓ+jets	$\ell\ell$	alljets	ℓ+jets	$\ell\ell$	ℓ+jets	$\ell\ell$	alljets	L_{XY}	ℓ+jets	$\ell\ell$	MEt
Pull	+0.40	−0.51	+1.11	+1.32	−0.38	−0.51	−0.82	−0.41	−0.67	1.42	+0.30	+0.45
Weight [%]	−4.7	−1.1	−0.9	+0.4	−0.2	+62.0	−0.3	+10.5	+0.22	+20.6	+1.4	+11.9

Systematic uncertainties of combined measurement

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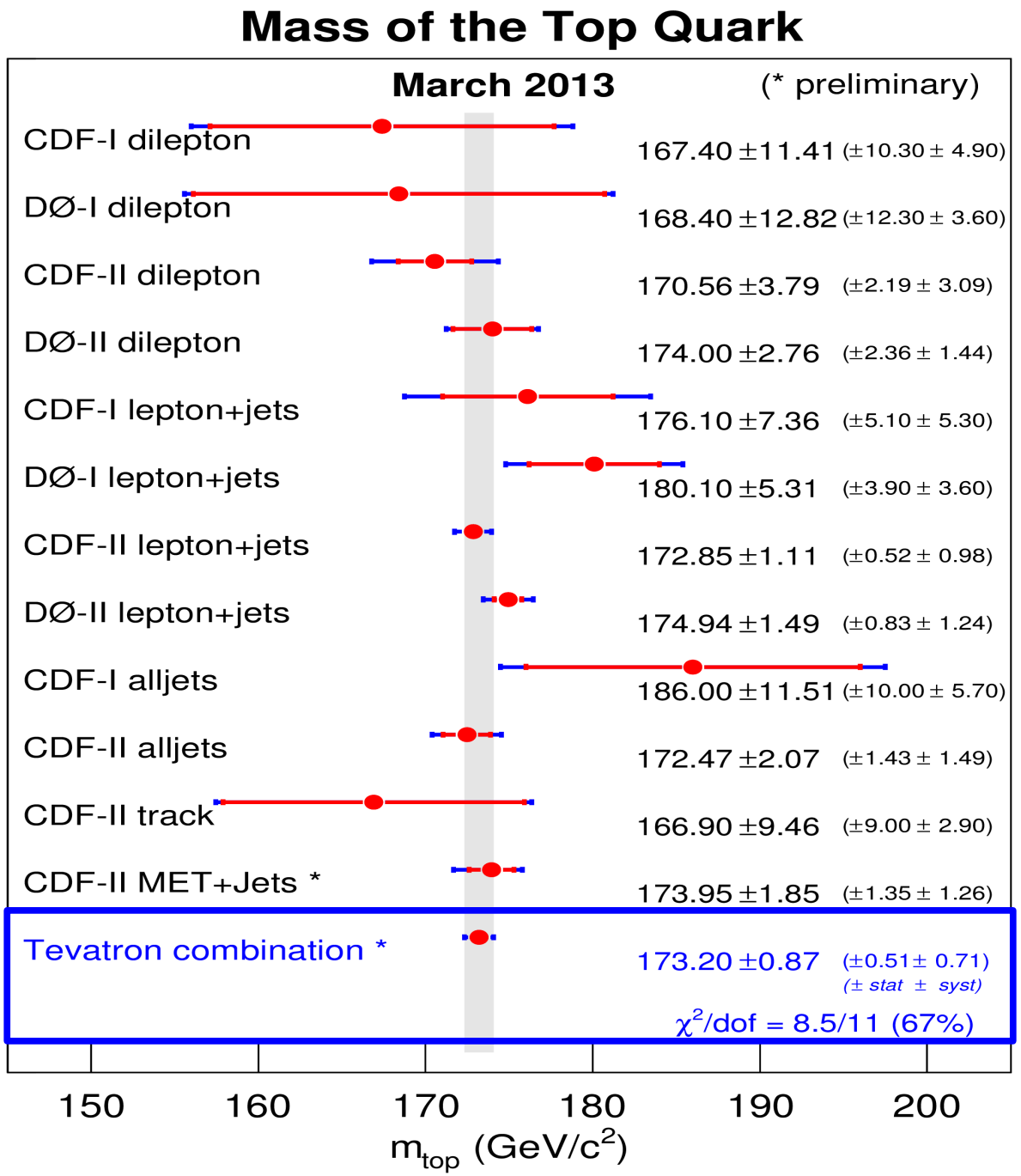
	Tevatron combined values (GeV/c^2)
M_t	173.20
In situ light-jet calibration	0.36
Response to b/q/g jets	0.09
Model for b jets	0.11
Out-of-cone correction	0.01
Light-jet response (2)	0.15
Light-jet response (1)	0.16
Lepton modeling	0.05
Signal modeling	0.52
Jet modeling	0.08
Offset	0.00
Background from theory	0.06
Background based on data	0.13
Calibration method	0.06
Multiple interactions model	0.07
Systematic uncertainty	0.71
Statistical uncertainty	0.51
Total uncertainty	0.87

The highest sources of the systematic uncertainty

Result



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Parameter	Value (GeV/c^2)	Correlations			
		M_t^{alljets}	$M_t^{\text{l+j}}$	$M_t^{\text{di-l}}$	M_t^{MEt}
M_t^{alljets}	172.7 ± 1.9	1.00			
$M_t^{\text{l+j}}$	173.2 ± 0.9	0.25	1.00		
$M_t^{\text{di-l}}$	170.0 ± 2.1	0.19	0.41	1.00	
M_t^{MEt}	173.8 ± 1.8	0.13	0.26	0.18	1.00

Relative precision of 0.5% !

Conclusions

- Preliminary combination of measurements of the mass of the top quark from the Tevatron experiments CDF and D0 is presented
- Combination includes 5 published Run I measurements, 6 published Run II measurements, and one preliminary Run II measurement.
- Mass of the top quark is known with a relative precision of 0.5 %
- Result is limited by systematic uncertainties
- The result will be further improved, when all analysis channels will be finalized using the full Run II data.

Thank you!

Back up

Negative weights of the measurements

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	Run I published					Run II published						Run II preliminary
	CDF			DØ		CDF				DØ		CDF
	ℓ+jets	$\ell\ell$	alljets	ℓ+jets	$\ell\ell$	ℓ+jets	$\ell\ell$	alljets	Lxy	ℓ+jets	$\ell\ell$	MEt
	ℓ+jets	$\ell\ell$	alljets	ℓ+jets	$\ell\ell$	ℓ+jets	$\ell\ell$	alljets	L_{XY}	ℓ+jets	$\ell\ell$	MEt
Pull	+0.40	−0.51	+1.11	+1.32	−0.38	−0.51	−0.82	−0.41	−0.67	1.42	+0.30	+0.45
Weight [%]	−4.7	−1.1	−0.9	+0.4	−0.2	+62.0	−0.3	+10.5	+0.22	+20.6	+1.4	+11.9

The negative weights occur if the correlation between two measurements is larger than the ratio of their total uncertainties → the less precise measurement will acquire a negative weight.

Systematic uncertainty categories (I)

In situ light-jet calibration – from in situ calibration procedures,
– uncorrelated among the measurements.

Response to b/q/g jets – part of the JES,
– differences in detector EM over HAD response between b-jets and light-quark jets.

Model for b jets – part of the JES,
– uncertainties specific to the modeling of b-jets (b-fragment., semileptonic branch. frac. color flow.),
– correlated across all measurements.

Out-of-cone correction – part of the JES,
– modeling uncer. associated with light-quark fragmentation and out-of-cone corrections,
– correlated across all measurements.

Light-jet response (1) – remaining part of the JES,
– corr. between all meas. of the same experiment,
– uncorrelated between experiments,
– specific to CDF.

Light-jet response (2) – part of the JES,
– originates from limit. in the data samples used for calib.
– corr. between meas. within the same data-taking
– uncorrelated between experiments.

Systematic uncertainty categories (II)

Lepton modeling – arising from uncer. in scale of lepton p_T meas.

Signal modeling – arising from uncer. in tt-bar modeling (amount of ISR/FSR, choice of PDF, choice of MC generator),
– correlated across all measurements.

Jet modeling – arising from uncer. in modeling of the detector in the MC simul.

Background from theory – uncertainty in modeling the background sources,
– correlated between all meas. in the same channel.

Background based on data – uncer. associated with modeling using data of the QCD multijet background,
– uncorrelated between experiments.

Calibration method – arising from any source specific to a particular fit method, including finite MC stats available to calibrate each method.

Offset – specific to D0
– arising from uranium noise in D0 calorimeter and from MI corr. to JES.

Multiple interactions model – arising from a mismodeling of distrib. of number of collisions per Tevatron bunch crossing
– uncorrelated between experiments.